Assignment 3; Phys 185 Name ______________

1. (10 points) The diagrams below show a binary star system. The white star is is more massive than the one shown as a black circle, but not hugely more massive. The stars revolve around their common center of mass. On diagram (a), draw and label the velocity and acceleration vectors for each star. On (b), show the forces on each star. Assume that the stars are in deep space and we can ignore the effects of the rest of the universe on either star. Draw the sizes of your arrows such that I can tell whether v, a, and F for each star is larger, smaller, or equal to the other.

(a)

(b)

Explain your reasoning:

2. (40 points) You have a book sliding on a table, and the coefficient of kinetic friction between the book and the table is μ_k. The table makes an angle of ϕ with the *vertical* (not the horizontal!). ϕ is small enough that if you placed the book at rest on the table, it would slide down. You now launch the book up the slope of the table with an initial speed v_0.

(a) What distance along the table will the book travel before it starts sliding back down?

(b) on next page

(b) The book now slides down. Find its velocity as it passes the point it was launched from. (In other words, the book slides down the same distance it traveled up in part a).

3. (30 points) You drop a spherical 4.1 kg object from a bridge with height 84 m over the water. Take $C_D = 0.5$, the density of air $\rho = 1.22\ \text{kg/m}^3$, and the radius of the object to be 0.25 m.

(a) Assuming you can ignore air resistance, calculate the speed at which the sphere will hit the water, and the time it will take to reach the water.

(b) But we really can't ignore the air resistance. Calculating the motion by accounting for drag force requires calculus, so we won't do that. Instead, circle the most accurate *approximate model* from amongst the following options:

i. Assume constant acceleration of g until the sphere reaches terminal velocity, and afterwards have it continue falling with this constant terminal velocity.

ii. Assume a constant velocity equal to the terminal velocity downward throughout the fall.

iii. Assume constant acceleration throughout, but reduce the downward acceleration to $g - \frac{1}{2}C_D m$, where m is the mass, to account for the drag force.

iv. Assume constant acceleration throughout, but reduce the acceleration to $g\frac{1}{2}C_D$, to account for the effect of the drag force.

Explain why you think your choice is the best approximation among these options.

(c) Use your choice of approximate model to calculate the speed at which the sphere will hit the water, and the time it will take to reach the water. Compare these to your answers from (a)—do they make sense?

4. (20 points) You set up a device where you have a bucket tethered to a rope, and the bucket rotates at a constant speed v in a vertical circle with radius r. You then place a small ball with mass m in the bucket. What is the minimum v you must have in order for the ball not to fall out of the bucket during rotation?